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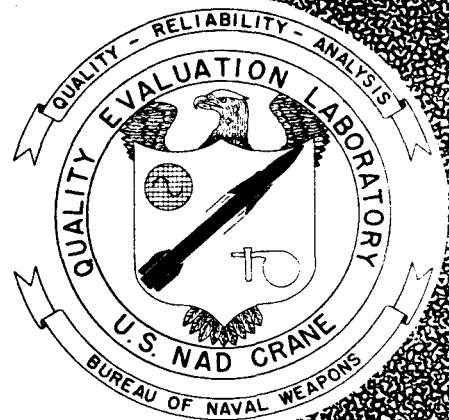
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EVALUATION PROGRAM
FOR
NICKEL CADMIUM SEALED CELLS

ACCEPTANCE TEST
OF
GULTON INDUSTRIES
20.0 AMPERE HOUR CELLS

[Signature] QE/C 63-317) OTS: 14 June 1963

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PREPARED UNDER THE DIRECTION OF

E C Bruess

E. C. BRUESS
Manager, Electrochemical
Power Sources Branch

APPROVED BY

O. N. FOWLER
COMMANDING OFFICER

C. G. Lynch

C. G. LYNCH
BY DIRECTION

ENCLOSURE (1)

REPORT BRIEFSEALED NICKEL CADMIUM BATTERY PROGRAMOFCELLS DESIGNED FOR USE IN SPACECRAFT

- Ref: (a) National Aeronautics and Space Administration Purchase Order Number W11,252B
(b) NASA ltr BRA/VBK/pad of 25 September 1961 to CO NAD Crane w/BUWEPS first end FQ-1:WSK of 2 October 1961
(c) Preliminary Work Statement for Battery Evaluation Program of 25 August 1961

I. TEST ASSIGNMENT BRIEF.

A. In compliance with references (a) and (b), evaluation of Sealed Nickel Cadmium Cells was begun according to the program outline of reference (c).

B. The object of this evaluation program is to gather specific information concerning sealed nickel cadmium cells designed for use in spacecraft. Information concerning the performance characteristics and limitations, including cycle life under various electrical and environmental conditions, will be of interest to power systems designers and users. Cell weaknesses, including causes of failure of present designs, will be of interest to suppliers as a guide to product improvement.

C. A total of 1100 cells were purchased by National Aeronautics and Space Administration (NASA) from four manufacturers, and consist of seven sample classifications ranging from 3 to 20 ampere hours.

D. The program is divided into three main sections consisting of Acceptance Tests, General Performance Tests and Cycle Life Tests.

E. This report is the third of a series of seven of the Acceptance Test Section. It gives the results of the acceptance tests of 100 twenty ampere hour size cells supplied by Gulton Industries, Inc., Metuchen, New Jersey. The cells are rated at 20.0 ampere hours by the manufacturer.

II. CONCLUSIONS.

A. From the results of this test, it can be concluded that:

1. The rated discharge capacity of the cells is repeatable when given special handling procedures to obtain that repeatability.

2. The capacity of the cells was in the acceptable range of 20.1 to 26.8 ampere hours.

III. RECOMMENDATIONS.

A. It is recommended that a study be made of the cell characteristics to enable the cells to perform with repeatable discharge capacities without the necessity of special handling procedures.

RESULTS OF ACCEPTANCE TESTS
OF
20.0 AMPERE HOUR SEALED NICKEL CADMIUM CELLS
MANUFACTURED BY
GULTON INDUSTRIES, INC.

I. INTRODUCTION.

A. On 26 September 1962, this activity began acceptance tests on 55 cells, the first received of a total of 101 necessary for final acceptance of the 100 required (one cell was damaged in transit). The acceptance tests were completed on 1 April 1963.

B. The NASA purchase contract was let during April 1962 stipulating delivery within 90 days. The cells, however, were received intermittantly between August 1962 and February 1963.

II. TEST CONDITIONS.

A. All acceptance tests were performed at an ambient temperature between 23° C. and 27° C. at existing relative humidity and atmospheric pressure, and consisted of the following.

1. Capacity Test.
2. Cell Short Test.
3. Immersion Seal Test.
4. Overcharge Test.
5. Litmus Leakage Test.
6. Internal Resistance Test.

B. All charging and discharging was done at constant current ($\pm 5\%$). Cells were charged in series but discharged individually.

III. CELL IDENTIFICATION AND DESCRIPTION.

A. The cells were identified by the manufacturer's serial numbers from 378 to 523, although not consecutively.

B. The 20.0 ampere hour cell is rectangular in shape with an average height (base to top of positive terminal), length and width of 7.10, 0.90 and 2.98 inches respectively. The average weight is 871.6 grams. Figure 1 is a photograph of a Gulton Industries, Inc. 20.0 ampere hour cell.

C. The cell container or can, and the cell cover are made of stainless steel. Both terminals are insulated from the cell cover by a ceramic seal and protrude through the cover as solder type terminals.

D. These cells, rated by the manufacturer at 20.0 ampere hours, were supplied in a discharged condition.

IV. TEST PROCEDURES AND RESULTS.

A. Capacity Test.

1. The capacity test is a determination of the cell capacity at the $c/2$ discharge rate, where c is the manufacturer's rated capacity, to a cutoff voltage of 1.00 volt per cell.

2. The first discharge capacity check was made by the manufacturer. The second discharge was made after a 1-hour open circuit period following a 1-week charge at the $c/20$ rate in accordance with the manufacturer's instructions for preparing the cells for use. The third discharge was made after a 1-hour open circuit period following a 16-hour recharge at the $c/10$ rate. Since the capacity of discharge number three was up to 20% less than that of discharge number two, of the first group of cells tested, the manufacturer recommended the following method to regain or prevent the loss of capacity on discharge number three. The cells were given a constant potential charge of 1.45 volts for 2 hours followed by a 16-hour constant current charge at the $c/10$ rate. Since this procedure restored the "lost capacities", it was adopted as the method of recharging the cells prior to the discharge of capacity check number three. A total of three capacity checks were made including one by the manufacturer. The cells were discharged individually but were recharged in series.

3. The cell capacities of the second and third capacity checks, made by this activity, generally were similar or slightly lower than those submitted by the manufacturer. The individual cell capacities ranged from 20.1 to 26.8 ampere hours for an average of 23.5 ampere hours. The cell capacities are tabulated in Table I in order from the highest to the lowest value. Characteristic 2-hour rate discharge curves are shown in Figure 2.

B. Cell Short Test.

1. The cell short test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, damage to element in handling or assembly.

2. Following completion of the third capacity discharge test, each individual cell was shorted for 16 hours. Each cell was then placed on charge at the c/5 rate for 1 minute followed by an open circuit stand for 24 hours, during which time voltage readings were taken every 3 hours. Any cell with voltage readings below 1.0 volt at the end of 24 hours was rejected.

3. The open circuit cell voltages 24 hours after the 1-minute charge at c/5 rate following the 16 hour shorted period, ranged from 1.11 to 1.23 volts for an average of 1.19 volts. The cell voltages, in most cases, were within ± 0.03 volts of the average value of 1.19 volts.

4. Of the 100 cells submitted to the cell short test, there were no rejects. The voltage values for the 100 accepted cells are shown in Table I.

C. Immersion Seal Test.

1. The immersion seal test is a means of detecting leakage of a seal or weld. The test was performed before the Overcharge Test sequence to show if the leak was present before the overcharge sequence.

2. The cells were placed under water in a bell jar container. A vacuum of 20 inches of mercury was held for 3 minutes. Cells discharging a steady stream of bubbles were considered rejects. The cells were then washed in distilled water and dried.

3. There were no failures out of the total of 100 cells subjected to the immersion seal test.

D. Overcharge Test.

1. The overcharge tests were performed to determine the steady state voltage at specified rates. The test specified a series of constant current charges at c/20, c/10 and c/5 rates, for a minimum of 48 hours at each charge rate or until the increase of the "on-charge" voltage was less than 10 millivolts per day.

2. The cells were monitored hourly throughout the test. Charging was discontinued on cells which exceeded 1.50 volts while on charge. The

following four cells were removed from charging during the c/5 section of the overcharge sequence at the times listed below.

- a. Cell number 420 reached 1.54 volts after 7 hours.
- Cell number 431 reached 1.55 volts after 8 hours.
- Cell number 447 reached 1.56 volts after 8 hours.
- Cell number 490 reached 1.56 volts after 8 hours.

3. The steady state voltage of each cell at the end of each 48-hour charge rate is shown in Table I. Characteristic overcharge voltage curves are shown in Figure 3.

E. Internal Resistance Test.

1. This test was performed to determine the internal resistance of the cell.

2. At the completion of the Overcharge Test, the cells were returned to the c/20 charging rate and given a short pulse (5 - 10 seconds) at a rate of c in amperes. The cell voltages, V_1 , immediately prior to the pulse; and V_2 , 5 milliseconds after the pulse, were read on a suitable recording instrument. A CEC high speed tape recorder (28.8 inches of tape per second) was used. The internal resistance of the cell in ohms was calculated according to the following formula.

$$R = \frac{V_2 - V_1}{I_c - I_{c/20}}$$

V_1 and V_2 are in volts, I_c and $I_{c/20}$ are in amperes.

3. The internal resistance value for each cell is shown in Table I. The values range from 1.58 milliohms to 14.74 milliohms.

F. Litmus Leakage Test.

1. The litmus test was used to determine electrolyte leakage at the terminal seals and welds after the overcharge tests.

2. The areas of closure of all cells were wiped with wet litmus paper at the completion of the Internal Resistance Test. Any discoloration of the litmus paper was considered as evidence of cell leakage and such cells were rejected.

3. There were no failures of the total of 100 cells subjected to the litmus test.

V. SECOND SECTION OF TEST.

A. General Performance Tests, the second section of the Sealed Nickel Cadmium Battery Test Program, are being conducted on five cells, the results of which will be summarized in the succeeding report.

APPENDIX

I. Table I contains cell dimensions and the results of the eight sections of the Acceptance Tests.

II. FIGURES.

A. Figure 1 is a photograph of the Gulton Industries, Inc., 20.0 ampere hour cell.

B. Figure 2 shows the characteristic 2-hour rate discharge curves.

C. Figure 3 shows the overcharge voltage curves.

TABLE I

CELL NUMBER	WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TESTS		CELL SHORT TEST	IMMERSTION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
					FIRST BY MANUFACTURER	SECOND BY NAD CRANE							
463	872.6	7.10	0.89	3.00	25.50	26.8	24.5	1.19	NONE	1.41	1.41	8.42	NONE
433	872.8	7.11	0.89	2.98	27.16	26.5	25.0	1.20	NONE	1.41	1.40	2.11	NONE
436	874.4	7.10	0.88	2.98	27.00	26.2	24.5	1.20	NONE	1.41	1.42	2.63	NONE
398	868.7	7.10	0.88	2.99	25.00	25.5	26.2	1.20	NONE	1.42	1.40	3.16	NONE
428	886.2	7.10	0.88	2.99	26.67	25.8	23.3	1.20	NONE	1.41	1.39	2.11	NONE
516	871.6	7.09	0.88	2.98	24.83	25.8	23.0	1.18	NONE	1.42	1.42	3.16	NONE
407	872.4	7.07	0.89	2.99	26.33	25.7	23.3	1.20	NONE	1.41	1.41	2.63	NONE
438	873.7	7.09	0.88	2.99	27.67	25.5	24.2	1.19	NONE	1.45	1.44	2.63	NONE
424	872.4	7.09	0.88	3.01	25.50	25.5	24.2	1.18	NONE	1.40	1.42	2.63	NONE
435	883.6	7.08	0.88	3.00	26.83	25.5	24.5	1.20	NONE	1.41	1.41	2.63	NONE
402	872.4	7.10	0.88	3.00	24.83	24.5	25.3	1.20	NONE	1.41	1.42	2.63	NONE
417	875.0	7.10	0.88	2.99	26.50	25.3	21.8	1.21	NONE	1.43	1.43	3.68	NONE
427	875.5	7.10	0.88	3.00	25.50	25.3	24.5	1.11	NONE	1.41	1.40	3.68	NONE
464	870.1	7.11	0.88	2.98	25.00	25.2	23.7	1.18	NONE	1.41	1.41	3.11	NONE
462	871.1	7.12	0.88	2.99	24.83	25.2	23.3	1.19	NONE	1.42	1.41	2.63	NONE
415	871.4	7.09	0.88	3.00	26.33	20.8	25.2	1.19	NONE	1.41	1.40	2.63	NONE
400	869.8	7.12	0.88	3.00	23.83	24.2	25.2	1.20	NONE	1.42	1.41	2.63	NONE
501	883.3	7.11	0.95	2.98	22.00	21.7	25.0	1.18	NONE	1.41	1.41	8.42	NONE
420	869.5	7.09	0.88	3.00	25.67	25.0	22.2	1.19	NONE	1.41	1.42	1.58	NONE
399	873.9	7.11	0.88	2.99	22.00	21.5	25.0	1.22	NONE	1.41	1.39	3.16	NONE

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMPRESSION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
					FIRST BY MANUFACTURER	SECOND BY MAD CRANE	THIRD BY MAD CRANE							
391	875.8	7.09	0.88	2.99	24.33	24.2	25.0	1.20	NONE	1.41	1.41	1.40	2.63	NONE
385	871.1	7.12	0.88	3.00	24.33	24.8	22.0	1.21	NONE	1.42	1.41	1.40	3.16	NONE
382	873.0	7.09	0.88	3.01	24.50	24.3	24.8	1.20	NONE	1.41	1.42	1.40	2.63	NONE
439	865.8	7.10	0.88	3.00	25.67	24.8	24.0	1.19	NONE	1.41	1.42	1.43	8.42	NONE
423	872.9	7.08	0.89	2.99	25.83	24.8	23.2	1.20	NONE	1.40	1.41	1.39	2.63	NONE
397	868.2	7.08	0.88	3.00	24.67	24.7	24.0	1.20	NONE	1.44	1.45	1.45	2.11	NONE
491	872.8	7.08	1.02*	2.98	22.17	22.3	24.7	1.18	NONE	1.42	1.42	1.42	10.00	NONE
432	882.1	7.08	0.88	2.99	24.00	24.7	24.7	1.21	NONE	1.41	1.40	1.40	2.11	NONE
494	874.5	7.10	1.00*	2.98	21.83	21.8	24.7	1.18	NONE	1.41	1.42	1.42	8.95	NONE
522	872.5	7.10	0.88	3.00	25.16	24.0	24.5	1.19	NONE	1.41	1.41	1.42	8.42	NONE
393	872.5	7.09	0.88	3.00	24.83	24.5	23.2	1.21	NONE	1.44	1.44	1.45	2.63	NONE
403	877.1	7.10	0.88	2.99	24.33	24.5	20.3	1.21	NONE	1.40	1.42	1.43	2.11	NONE
456	874.0	7.11	0.88	2.99	24.67	20.5	24.5	1.19	NONE	1.43	1.43	1.42	2.63	NONE
503	878.0	7.11	0.88	2.98	21.00	20.2	24.5	1.18	NONE	1.41	1.41	1.41	8.42	NONE
487	877.2	7.10	1.04*	2.97	22.83	23.0	24.3	1.18	NONE	1.42	1.42	1.42	10.00	NONE
392	874.6	7.09	0.88	2.99	24.00	24.3	23.3	1.19	NONE	1.44	1.44	1.45	8.42	NONE
434	881.4	7.09	0.88	2.99	25.00	23.3	24.3	1.20	NONE	1.41	1.41	1.41	3.16	NONE
449	877.5	7.12	0.89	2.99	24.16	20.2	24.3	1.20	NONE	1.39	1.41	1.41	1.58	NONE
519	868.1	7.09	0.89	2.98	25.00	24.2	23.2	1.19	NONE	1.41	1.41	1.42	2.11	NONE
515	873.5	7.09	0.88	3.00	24.83	24.2	23.0	1.19	NONE	1.42	1.42	1.43	2.63	NONE

* Slight bulge.

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TESTS		CELL SHORT TEST	IMERSION SEAL TEST LEAKAGE	OVERCHARGE			INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
					FIRST BY MANUFACTURER	SECOND BY NAD CRANE			c/20	c/10	c/5		
413	868.7	7.10	0.88	2.99	24.50	24.2	23.0	1.19	NONE	1.41	1.43	1.42	2.63
384	877.5	7.11	0.88	3.00	24.83	24.2	22.5	1.22	NONE	1.42	1.43	1.44	2.63
484	871.6	7.09	0.99*	2.98	23.17	24.0	20.0	1.19	NONE	1.44	1.44	1.44	2.63
486	874.4	7.10	1.04*	2.97	23.67	24.0	21.7	1.21	NONE	1.43	1.43	1.44	8.95
430	870.0	7.09	0.88	3.00	22.33	23.8	22.8	1.20	NONE	1.43	1.43	1.43	3.68
426	869.4	7.08	0.88	2.99	24.33	23.0	23.8	1.20	NONE	1.41	1.40	1.40	3.16
418	876.5	7.09	0.88	3.00	25.16	23.8	21.7	1.18	NONE	1.41	1.40	1.39	2.11
521	868.3	7.10	0.88	2.99	24.33	23.8	23.2	1.19	NONE	1.41	1.42	1.43	3.16
416	873.8	7.10	0.88	3.00	24.67	23.7	21.7	1.19	NONE	1.41	1.40	1.40	2.63
534	872.5	7.10	0.88	2.99	24.83	23.7	22.7	1.22	NONE	1.40	1.40	1.40	12.63
379	875.3	7.10	0.88	2.99	22.67	22.7	23.5	1.19	NONE	1.42	1.43	1.42	2.63
380	878.5	7.09	0.88	2.98	24.87	22.0	23.5	1.20	NONE	1.44	1.44	1.44	3.68
437	865.4	7.09	0.88	3.00	23.50	23.3	22.5	1.20	NONE	1.41	1.42	1.42	3.16
401	873.3	7.08	0.88	2.99	23.00	23.3	23.2	1.21	NONE	1.41	1.40	1.41	2.11
378	872.8	7.10	0.88	2.99	22.16	21.5	23.3	1.20	NONE	1.42	1.43	1.44	11.58
452	881.4	7.10	0.88	2.99	23.83	20.3	23.3	1.20	NONE	1.41	1.41	1.41	8.42
457	869.4	7.11	0.88	2.99	24.33	20.3	23.3	1.20	NONE	1.41	1.41	1.41	3.11
480	874.7	7.10	1.00*	2.98	22.17	21.8	23.3	1.18	NONE	1.43	1.43	1.43	3.68
493	882.4	7.10	1.07*	2.97	23.67	23.2	20.7	1.19	NONE	1.40	1.42	1.43	2.11
488	867.5	7.11	1.01*	2.98	22.50	23.0	21.3	1.22	NONE	1.40	1.42	1.42	2.11

* Slight bulge.

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TESTS			CELL SHORT TEST	IMMERSION SEAL LEAK LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
					FIRST BY MANUFACTURER	SECOND BY NAD CRANE	THIRD BY NAD CRANE							
523	869.7	7.11	0.88	2.99	23.67	23.0	23.0	1.20	NONE	1.41	1.41	1.42	3.42	NONE
513	875.3	7.10	0.88	2.99	24.00	22.8	22.7	1.19	NONE	1.41	1.41	1.41	2.63	NONE
511	864.7	7.11	0.88	3.00	23.83	22.8	21.8	1.19	NONE	1.41	1.41	1.42	8.42	NONE
508	859.9	7.10	0.89	3.00	20.67	20.8	22.8	1.18	NONE	1.41	1.41	1.41	14.74	NONE
490	870.9	7.08	1.06*	2.97	22.67	22.8	20.5	1.18	NONE	1.41	1.42	1.56 @ 8 Hrs.	2.63	NONE
467	878.2	7.12	0.89	2.98	23.67	20.3	22.8	1.19	NONE	1.42	1.42	1.42	12.63	NONE
399	874.8	7.08	0.88	2.99	24.50	22.8	22.7	1.22	NONE	1.43	1.43	1.44	3.68	NONE
390	874.6	7.10	0.88	3.00	21.83	22.3	22.7	1.22	NONE	1.41	1.39	1.39	3.16	NONE
395	869.3	7.11	0.88	3.00	21.50	20.0	22.7	1.22	NONE	1.41	1.40	1.40	2.63	NONE
412	879.8	7.09	0.88	3.00	24.33	22.5	22.5	1.17	NONE	1.41	1.42	1.43	2.63	NONE
447	873.4	7.12	0.89	2.99	23.67	21.2	22.5	1.20	NONE	1.39	1.41	1.56 @ 8 Hrs.	2.63	NONE
489	878.2	7.10	1.04*	2.98	22.50	22.3	20.7	1.18	NONE	1.43	1.43	1.44	8.42	NONE
469	879.6	7.11	0.88	2.99	24.50	21.2	22.3	1.20	NONE	1.42	1.42	1.42	3.68	NONE
465	868.1	7.10	0.88	2.98	24.50	22.2	20.0	1.18	NONE	1.42	1.42	1.41	3.11	NONE
396	868.2	7.11	0.88	3.00	21.67	22.2	20.0	1.23	NONE	1.42	1.42	1.42	2.63	NONE
383	871.1	7.10	0.88	3.00	21.50	20.2	22.2	1.19	NONE	1.41	1.40	1.39	2.63	NONE
387	877.1	7.09	0.88	2.99	23.67	20.8	22.2	1.19	NONE	1.44	1.44	1.44	3.68	NONE
429	874.1	7.09	0.88	2.99	23.16	20.3	22.2	1.22	NONE	1.39	1.41	1.42	3.16	NONE
483	879.0	7.09	1.02*	2.98	23.00	21.0	22.0	1.18	NONE	1.42	1.43	1.42	12.63	NONE
466	872.4	7.12	0.89	2.99	25.00	21.0	22.0	1.17	NONE	1.43	1.42	1.42	12.63	NONE

* Slight bulge.

TABLE I (CONTD)

CELL NUMBER	WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TESTS		CELL SHORT TEST	IMMERSTION SEAL TEST LEAKAGE	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	LITMUS LEAKAGE
					FIRST BY MANUFACTURER	SECOND BY NAD CRANE							
422	872.2	7.11	0.88	3.00	25.83	22.0	21.3	1.18	NONE	1.43	1.44	2.11	NONE
404	871.2	7.11	0.88	2.99	26.16	22.0	20.3	1.19	NONE	1.44	1.44	3.68	NONE
386	873.1	7.10	0.88	3.00	24.67	20.8	22.0	1.20	NONE	1.45	1.45	3.68	NONE
454	873.6	7.11	0.88	2.99	23.83	20.0	21.7	1.17	NONE	1.42	1.41	3.68	NONE
394	875.4	7.09	0.88	2.98	24.50	20.5	21.7	1.21	NONE	1.43	1.43	2.63	NONE
388	869.7	7.11	0.88	3.00	21.83	21.7	21.2	1.20	NONE	1.40	1.39	2.63	NONE
468	867.5	7.12	0.89	2.98	23.83	21.5	20.0	1.17	NONE	1.40	1.41	2.11	NONE
450	874.7	7.08	0.88	2.99	24.16	21.5	20.5	1.17	NONE	1.42	1.41	8.42	NONE
440	877.5	7.10	0.88	2.98	25.16	20.3	21.3	1.19	NONE	1.43	1.43	2.63	NONE
419	872.7	7.12	0.88	3.00	23.50	21.3	20.2	1.19	NONE	1.40	1.41	1.58	NONE
458	869.3	7.11	0.88	2.99	23.67	20.2	21.3	1.17	NONE	1.43	1.42	8.42	NONE
496	878.7	7.09	1.00*	2.98	22.83	21.3	20.7	1.21	NONE	1.43	1.43	12.63	NONE
495	876.9	7.10	0.95*	2.98	21.67	21.2	20.0	1.22	NONE	1.42	1.42	12.63	NONE
441	872.7	7.11	0.88	3.00	23.00	20.3	21.2	1.21	NONE	1.42	1.43	8.42	NONE
381	874.2	7.10	0.88	3.00	21.67	20.8	21.0	1.21	NONE	1.41	1.39	3.16	NONE
448	872.1	7.11	0.88	2.99	24.67	21.0	20.8	1.16	NONE	1.44	1.42	3.11	NONE
460	871.4	7.11	0.88	2.99	24.83	20.2	21.0	1.17	NONE	1.42	1.41	3.68	NONE
431	874.0	7.09	0.88	3.00	25.00	20.2	20.2	1.19	NONE	1.40	1.41	2.23	NONE
461	877.1	7.09	0.88	2.98	24.83	20.2	20.0	1.18	NONE	1.42	1.41	3.11	NONE
446	872.3	7.10	0.89	2.98	24.16	20.0	20.0	1.18	NONE	1.43	1.43	3.16	NONE

* Slight bulge.

QE/C 63-317



FIGURE 1

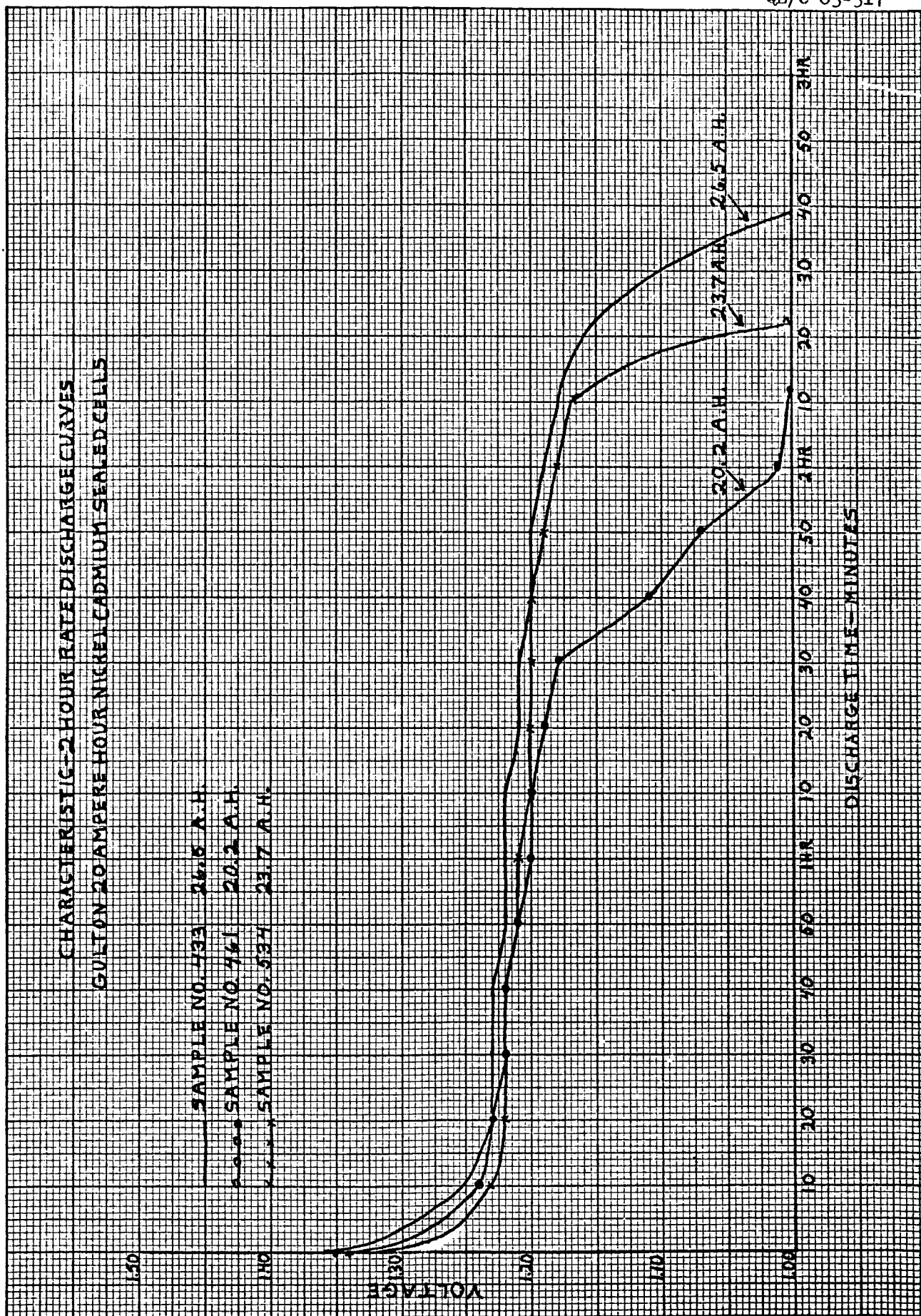


FIGURE 2

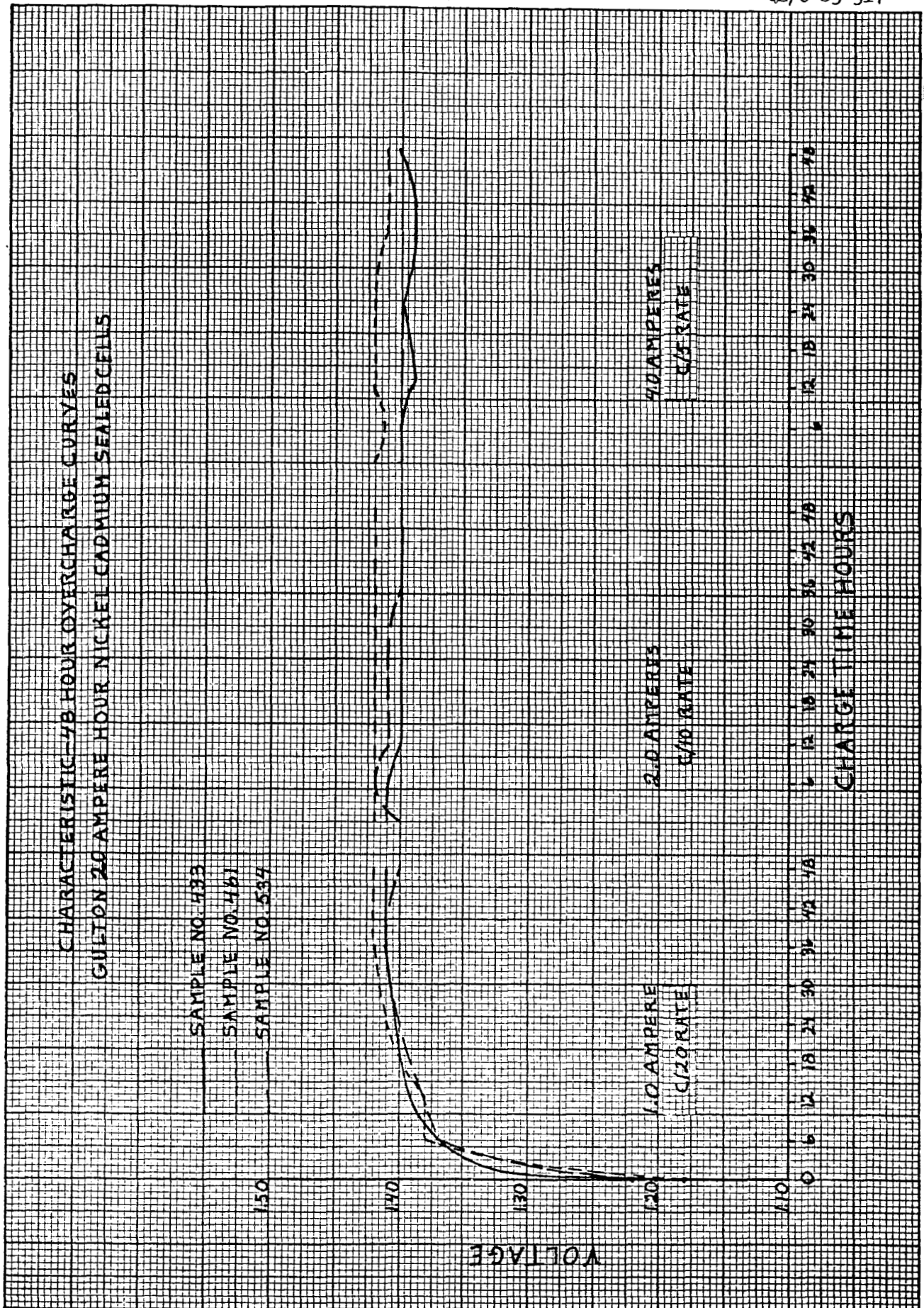


FIGURE 3

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